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SURVEYING AND MAPPING FOR ECONOMIC DEVELOPMENT AND NATURAL RESOURCES CONSERVATION

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SURVEYING AND MAPPING FOR ECONOMIC DEVELOPMENT AND NATURAL RESOURCES CONSERVATION

by
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1. Introduction. In this report, we would like to present a brief summary of the activities in surveying and mapping especially aimed directly at the economic development and natural resources conservation in Japan, which have recently made a rapid progress by aerial photographs in addition to the conventional geodetic surveyings. It also gives techniques in their connection.

2. Increase of requirements for large scale maps, aerial photographs, as well as topical maps for special purposes, is urgent under the severe circumstances that the population of more than 90 millions must live within narrow islands of about 370,000 sq.km. in total, of which two thirds are steep mountains and 47% of the whole population is obliged to concentrate in 1% of the whole area. Consequently most cities have been established and developed in low alluvial plain. This results that the increase of pumping out of under-ground water due to industrialization has brought a serious problem of the subsidence of ground in some cities. Similar problem also arises owing to exploitation in mining areas.

3. When we effectively avail ourselves of the limited land and natural resources, a full scientific investigation of our land is very important and thereon the integrated plannings must be proceeded. We hope that the experiences and the techniques obtained through these surveyings and mappings in Japan would be of use to the areas where the land development is of a great interest.

4. National large scale mapping project. Many aerial photographs and large scale maps were taken rather independently for various purposes. In order to satisfy their increasing requirements, avoiding unexpected repetition of surveys as well as to contribute to the governmental control on the synthetic use and conservation of land, a new "National Large Scale Mapping Project", with the purpose of the systematical coverage of the whole land by the standardized aerial photographs and large scale maps, has been carried out by the Geographical Survey Institute in co-operation with other governmental and public agencies.

(a) Subjects. The project consists of the following subjects:

(i) Aerial photographing. The aerial photographing is planned to cover the whole land in 5 years on scale 1:10,000 for the flat terrains of about 95,000 sq.km. and on scale 1:20,000 for the remaining mountainous areas. The flight direction is mainly planned as East-West.

(ii) Ground control surveying. The ground control surveyings are planned, with close connection to the cadastral survey and the existing controls, to complete the 4th order triangulation net works and the 2nd order levelling routes. At the first step, however, control points will be established mostly in narrow selected zones which are about 10 minutes apart in longitude from one another, to enable the aerial triangulation of 10-15 models.

(iii) Mapping. The mapping is planned on scale 1:2,500 for the flat terrains and on scale 1:5,000 for the mountainous areas. Contour intervals are 2 m. for the former and 5 m. for the latter respectively, but these standard contour intervals may be reduced if necessary, for example up to 0.5 m.

(b) Specification. The standards of these works are consolidated in one specification "The Specification for the National Large Scale Mapping Project", including the whole procedures from control point surveying to reproduction of maps and combined to one another in such a way that they have no contradic-

tions or gaps between them. It is prepared in close connection with other surveying specifications, for example, that for the cadastral survey. The specification includes the minimum and the most important requirements for normal mapping procedures. When any special mappings, such as high-way planning or irrigation planning maps, are considered, the necessary additional items will be supplemented.

(c) Inspection. The inspection of such a big project requires many engineers and much time; for example, we shall have more than 40,000 sets of aerial photographs and 600 sheets of maps to inspect in 1962. As it is almost impossible to carry but any inspection for all of these photographs and maps, we have adopted a kind of sampling test as follows. The results are divided into several groups, a few samples are picked up from each group at random and these samples are tested on some critical items. The original groups are classified into three grades according to the results of the sampling test: The top grade is considered to stand for the specification and is accepted without any further tests. The lowest grade is rejected automatically without any further tests. The medium grade is decided case by case with further sampling tests or more precise examination.

(d) Execution. The project started in 1960. During that year some 1,800 sq.km. have been covered by photographs, 195 control points were established and the mapping of 450 sq.km. were finished on scale 1:2,500. These works were carried out as the test case for the succeeding routine works. In 1961, photographing on scale 1:10,000 covering the most important areas of about 31,600 sq.km., or nearly one third of the flat terrain were finished with 912 signalized points and 1,692 ground control points were newly established in some of the photographed areas. All works have been executed by private surveying companies contracting with the Geographical Survey Institute under its supervision. In 1962, similar amount of works as the preceding years with the additional mapping project of some 41,000 sq.km. are planned and going on.

5. Analytical aerial triangulation. Aerial triangulation is generally thought a very effective procedure for mapping by aerial photography. Especially in areas where one may expect only a small number of control points, the aerial triangulation takes a great important part. In Japan, however, the aerial triangulation is mainly purposed to supply control points for large scale mapping such as of 1:5,000 or even up to that of 1:1,000. These mappings are mostly used for high-way construction, irrigation plannings, rail-way construction and miscellaneous works in forestry etc. So that, the accuracy required for the aerial triangulation is relatively high. The scale of used photographs are mainly from 1:10,000 to 1:30,000 and the length of one strip is no longer than 15 models due to the required accuracy and the availability of dense national triangulation net works for the control points.

6. It is well known that the conventional aerial triangulation by the first order plotting instruments has been taken the place by the analytical method which is prominent in efficiency, accuracy and wide appliances for any kind of cameras with only needs for a simple comparator and an electronic computer of medium size.

7. At a certain private company the advantages of the analytical aerial triangulation have been recognized and it has been adopted as a part of their routine works since these three years. Compared with the conventional old method of which efficiency is at most 150 models per month per machine, the analytical method has a 10 times higher efficiency. Moreover, the resection data obtained by the analytical method are more convenient for plotting, because, at the time of plotting, orientation by the machine becomes needless. It saves about 1-2 hours for operation per model on the average. Before the analytical method was applied, the operation time for orientation occupied 20-50 % of the total hour for plotting one model. They used the Wild Autograph A7 as the comparator at first, but now they have developed their own point transfer device and comparator to measure each photograph one by one.

8. As an example of the activities on this line, the ANNEXED TABLE gives a part of the experiences during one year. The table is reproduced from a report by a private surveying company. Because of the tendency that the mapping on large scale has been mainly done by private companies, the data on the table are confined to that on scale 1:5,000 which is on the smallest scale. The table shows that the analytical method has a peculiar feature that gives some discriminative data for the accuracy of the aerial triangulation: residual vertical parallaxes and discrepancies in the pass points of the adjacent models. They are new criteria for the judgement of the accuracy of which it is unable to take into account by the conventional old method. These criteria may give the analytical method a new chance for its future development.

9. It is felt that super wide angle camera may be suitable for the areas where a large number of control points may not be available. Thereby it will need a new plotting device for the aerial triangulation. Otherwise it may only be done by the analytical method. It is also felt that in such case the analytical method will serve as a new powerful means.

10. Topical Mapping. Some of the results of the surveys have been published as topical maps and photo-maps as shown in TABLE 1, each item of which will be described as follows.

(a) Land use maps have covered one third of the country to be used for the development of the Special Areas for Development designated by the Multi-purpose Land Development Law and redevelopment of urban or industrial areas and so on.

(b) Land classification map on scale 1:50,000 has been compiled for some sample areas based on the Country Research Law. The map is one of the most fundamental maps for land development and conservation showing land form classification, drainage pattern, slope gradient in mountainous areas etc.

(c) Maps for flood prevention on scale 1:25,000 showing detailed land form classification and heights in low alluvial plains and distribution of public facilities for flood prevention have been made in River Tone Basin mainly by photo-interpretation and some field works in close connection to the surveys on the subsidence of ground (paragraphs 11-17). They are used not only for flood prevention works but also for redevelopment works of the Tokyo metropolitan area.

(d) Lake charts on scale 1:10,000 showing the topography of lake basin with 50 cm. intervals of contour lines have been completed at two large lakes. Echo sounders have been used for the field survey. The chart is used not only for the multi-purpose water control planning (planning for flood control, irrigation, water supply for urban or industrial region), but also the land reclamation planning of lake basin.

(e) Photo-maps on scale 1:25,000 have been compiled for five new areas where industrial development is going on. It is a mosaic of aerial photographs with overlay showing land form types, land use pattern etc. It is very useful as the base map of city or regional planning until large scale maps are available.

11. Surveys for the subsidence of ground. The geological structure of our country is exceedingly complex in comparison with other countries. The destructive earthquakes and volcanic eruptions have frequently occurred with remarkable land deformations. In addition to those abrupt land deformations, the chronical movements of the crust are detected by the revision surveys of levelling and triangulation that the mountainous region still has the tendency of upheaval and the low land has that of subsidence. Most of industrial cities have been established and developed in low land on alluvial plain consisting of new sediments of sand, gravel, clay and organic matters, reaching from scores of meters to several hundred meters thick in total, for economical reasons, as well as topographic conditions, in our country. A quantity of water pumped up for the industrial use from the lower part of sediment layers has promptly increased with the development of the industries, and it brought about the rapid subsidence of ground. Consequently these cities are setting into serious crisis because of

TABLE 1. Topical Maps for Economic Development and Natural Resources Conservation in Japan

Kind of survey	Land use	Land classification	Land classification for flood prevention	Photo-geography	Lake survey
Start from	1951-	1953-	1959-	1961-	1955-
Areas	areas for multi-purpose development and regional planning, 336 sheets covering 1/3 of the country except Hokkaido. Hokkaido 2 sheets	sample areas in 13 13 sets	lowland Nobi Plain 2 sheets Kanto Plain 11 sheets	urbanized areas newly industrialised areas Sendai, Toyama, Oita, Tokushima, Okayama (5 areas)	Lake Biwa 24 sheets Lake Kasumiga-ura 14 sheets
Expression	land use map " 1: 50,000 " 1: 25,000 " 1:200,000	land classification map 1: 50,000 drainage and valley density map 1: 50,000 slope gradient map 1: 50,000 explanatory text	(Nobi plain) inundation and flood disaster map 1:50,000 inundation type map 1:50,000 ground heights map 1:25,000 (Kanto plain) land classification for flood prevention map 1:25,000 ground heights and public facilities map 1:25,000 explanatory text	photo-map (land-use) 1:25,000 over-lay (land-form type) 1:25,000 explanatory text	lake chart 1:10,000
	land use land conservation public facilities	land-form classification drainage pattern slope gradient classification	land-form classification of alluvial plain distribution of facilities for flood prevention	land-form classification land use contour line	contour line of lake basin bottom materials

accumulation of damages caused by flood or storm surge and ununiform subsidence of buildings. Similar problems were found in coal mining regions, that is, the large deformation caused by mining devastates its mountain and agricultural land.

12. The counter measures for the purpose of restoring these cities and preserving the land from artificial land damage should be done based on thorough investigations. In order to clear up the actual state and the mechanism of the subsidence of ground, a large number of phenomena must be observed, because of the complexity of the geological structure of our country. The indispensable items for the investigation are as follows:

(a) Repetition of the precise levelling.
(b) Continuous observation of height of the under-ground water level.
(c) Continuous observation of the shrinkage of the ground layers.
(d) Triangulation.
(e) Tidal observation.
(f) Investigation of geological structure by means of boring, physical prospecting, gravity measurement and aerial photographing.
(g) Experimental studies of physical and chemical character of collected materials.
(h) Topographical, geographical and geological investigations.

13. According to these investigations the actual states of the subsidence and deformation of ground have been clarified and the results are greatly useful for restoration and prevention from disaster at the present time. But the most important problem is how to serve them for the future development of land use and for this purpose the investigations are now going on in more extensive scale.

14. Among those investigations, the levelling is the most practical work to be conducted.

15. For the case of Niigata District, where the subsidence of ground has been remarkable in recent years, the total area investigated amounts to about 1,600 sq.km. and the number of the first order and second order bench marks involved in the area where the periodical resurveying has been executed reaches to about 330 at the present time.

16. A five year program of relevelling was planned in 1959 as shown in TABLE 2.

TABLE 2

Period	1st order B.M.	2nd order B.M.	Remarks
6 months	66 km.	183 km.	The survey is carried out every March and Sept.
1 year	133	286	Including the region repeated every 6 months
2 years	231	385	Including the regions repeated every 6 months and 1 year

17. For the purpose of checking the datum point in this area which is assumed to be fixed the precise levels were carried out along the route connecting two mareographic stations in 1958 and 1961. All investigations have been made collectively. Particularly, the radical investigation of the cause and mechanism of the subsidence of ground called "Cosmos Plan" was planned in 1958. As one of interesting items of this plan the simultaneous observation of the effects accompanying the intentional operation and stoppage of pumping up of underground water were carried out.

ANNEXED TABLE

STATISTICS OF ANALYTICAL AERIAL TRIANGULATION FOR MAPPING (SCALE 1:5,000)

Through June 1961 - May 1962

(ASIA AIR SURVEY CO., LTD.)

Name of Project	No. of Strips	No. of Models	Fl. Heig. above Sea Level (m)	Elev. Min.	Elev. Max.	Camera Lens. f. (mm)	Method of Triang. Semi, Pure Single, Block	Res. Par. (Unit: μ)	Rel. Discrep. at Pass Pts. (Unit: 10⁻⁴ x ...ce)	Residual Errors Tie Pts. (Unit: m)	Residual Errors Contr. Pts. (Unit: m)	Ident. of Contr. Pts. Signal	Ident. of Contr. Pts. Prick	Ident. of Contr. Pts. Interp.	Remarks
KITAMURA-YAMA	17	171	5,300	50	1,200	Aviotar 209.77	Pure, Block	aver. 7 max. 37	x y z aver. 0.02 0.34 0.99 max. 0.40 1.54 3.91	X,Y Z aver. 0.85 1.41 max. 2.93 5.30	X,Y Z aver. 1.09 1.42 max. 3.96 5.90	□ 0 ▲ 50	0 0	0 20	Forest
KAJIMIYAMA	6	60	5,300	100	1,400	209.77	Pure, Block	6 30	0.02 0.34 1.10 0.25 1.70 4.13	0.32 1.37 2.77 4.94	1.02 1.41 2.68 4.72	0 23	0 0	0 1	Forest
ZAO	14	124	5,300	100	1,900	209.77	Pure, Block	7 38	0.05 0.29 0.95 0.10 1.56 3.96	0.91 1.62 2.68 5.90	1.05 1.34 4.38 5.51	0 33	0 0	0 12	Forest
NISHIURA-YAMA	14	168	5,300	200	2,000	209.77	Pure, Block	7 46	0.01 0.27 0.85 0.13 1.34 3.79	0.92 1.74 2.91 5,96	1.22 1.02 3.99 3.11	0 30	0 0	0 10	Forest
MOGAMI-GAWA	1	5	3,300	90	400	Avilogon 152.12	Pure, Single				1.13 0.60 2.14 1.56	0 5	6 5	0 0	River
MIYASAKUDAICHI	3	23	2,300	100	600	152.12	Pure Single	6 27	0.0. 0.26 0.51 0.05 1.01 1.88		1.23 0.62 3.26 2.10	0 0	0 17	0 0	Land Planning
SUWA-TEMPIC	5	39	3,000	0	700	152.29	Pure, Single	7 32			0.41 1.03 1.34 2.73	19 24	6 0	0 0	High Way
YAMA-KUCHAI	5	40	3.000	100	900	152.12	Pure, Single	7 37	0.02 0.24 0.45 0.92 1.00 2.50		0.71 0.51 2.65 2.10	17 23	3 2	0 0	High Way
TAKA-GAWA	9	37	3,800	75	300	152.29	Pure, Block	3 73	0.01 0.23 0.44 0.10 1.36 2.18	0.69 0.88 2.78 3.20	1.13 1.31 2.54 2.90	0 0	11 24	0 0	Dam
FUTABASAWAI	3	20	3,300	400	800	152.19	Pure, Single	8 31	0.02 0.27 0.44 0.03 0.92 1.47	0.53 0.75 1.90 2.78	0.56 0.50 1.70 1.75	0 3	17 9	0 0	Exploi-tation
ASHIKU	2	14	3,300	70	300	152.12	Pure, Single	9 44	0.01 0.36 0.50 0.05 1.00 1.40		1.08 0.87 2.91 2.81	0 0	4 19	0 0	Dam
HITAKOSHI	4	54	3,000	60	1,100	152.85	Pure, Block	6 29	0.01 0.31 0.56 0.14 1.92 2.94	0.39 0.43 1.07 2.47	0.93 0.37 2.56 3.07	0 0	20 17	0 0	Electric Trans-mission
...AZATA	4	40	3,300	20	1,150	152.19	Pure, Single	8 36	0.02 0.38 0.61 0.15 1.34 2.24	0.73 0.54 1.77 1.05	1.21 1.18 3.47 3.34	0 10	0 0	0 0	High Way
...OKU-JUKAN	1	13	3,300	130	700	152.12	Pure, Single	8 31			0.97 0.69 2.30 1.80	0 6	0 10	0 0	High Way

Explanation for Abbreviated Titles: Fl. Heig. ..... Flight Height Elev. ..... Elevation Triang. ..... Triangulation Res. Par. ..... Residual Parallax
Rel. Discrep. ..... Relative Discrepancies Tie Pts. ..... Tie Points Contr. Pts. ..... Control Points Ident. of Contr. Pts. ..... Identification of Control Points